Pipeline-Scale Flow Measurement Standards for Natural Gas

NIST is developing gas flow calibration tools known as critical flow venturis (CFV), or sonic nozzles, to calibrate natural gas flow meters used in the field. The uncertainties of measurements currently being made are as high as 0.5%. NIST CFVs will provide traceability for custody transfer of natural gas in large pipelines with uncertainties of 0.2 % or less.

A.N. Johnson (Div. 836)

In 2004, the U.S. consumed 630×10^9 cubic meters of natural gas. Of this total, approximately 16% was imported from Canada through pipelines at a cost of ~$21 billion. The volume of imported natural gas will continue to increase for the foreseeable future because the U.S. is the largest energy consumer; however, the U.S. holds only 3% of the world's natural gas reserves. (Energy Information Administration, www.eia.doe.gov.) At present, custody transfer of natural gas in pipelines relies on flow meters (*e.g.*, turbine meters, ultrasonic meters) with calibrations that are NOT traceable to SI units through NIST. The uncertainty of flow measurements provided by private flow laboratories is as large as 0.5 %. NIST, in collaboration with U.S. private flow laboratories, will reduce flow uncertainties to 0.2 % and will establish traceability for flows ranging from 0.7 m^3/s to 10.7 m^3/s.

The purpose of this work is to: provide NIST traceability for custody transfer of natural gas in large pipelines with uncertainties of 0.2 %, or less; reduce the costs associated with measurement uncertainties for international custody transfer of natural gas, and; facilitate the sale of U.S.-manufactured flow meters abroad by providing NIST calibrations or NIST-traceable calibrations of such meters.

Traceability between NIST and private flow laboratories is being established with four critical flow venturis (CFVs) calibrated at NIST.

Often, CFVs are used as transfer standards to compare the primary flow standards of National Metrology Institutes (NMIs) because CFVs are rugged and they have well understood physical mechanism controlling their operation and exhibit excellent long term reproducibility. A sequence of measurements has been designed that begins with CFVs calibrated at NIST in low pressure air and extending to high pressure natural gas with only small increases in uncertainty. Ultimately, the NIST calibrated CFVs will be used to calibrate other the flow standards (*e.g.*, turbine meters) located in private flow laboratories equipped for large flows of natural gas. Upon request, NIST will utilize flow calibration facilities at suitable private-sector laboratories to provide NIST calibrations of flow meters at lower uncertainties than those available today.

This work will provide a basis for improved access of U.S. gas flow meter manufacturers to world markets where international recognition of flow measurement standards for pipeline conditions in natural gas flows are required.

Thus far, a set of 4 CFVs have been calibrated at NIST. These results have been compared with those obtained on the set at two other NMIs. These results were mutually consistent within 0.05 %. NIST calibrations spaced two years apart demonstrate that the irreproducibility of these CFVs is less than 0.03 %. Having thoroughly characterized these CFVs, NIST has begun to calibrate secondary standards at one of the two privately owned flow laboratories in the U.S. equipped to measure pipeline scale (8-inch to 30-inch diameter) natural gas flows. To calibrate large flow meters that are subsequently used as working standards at these calibration laboratories, the NIST calibrated CFVs were arranged in a common plenum and used to calibrate several additional CFV flow meters at higher flows, which in turn were used to calibrate an array of turbine meter reference standards. The private-sector flow laboratory uses these reference standards to calibrate more than 70 % of the flow meters used for the custody transfer of natural gas in the U.S.

Future Directions

In the coming year we will assess possible flow interference effects resulting from using multiple CFVs in a common plenum, check the consistency of the new turbine meter calibrations by systematically comparing these reference standards to each other, and publish an uncertainty analysis of the measurement results. Then, NIST will be ready to initiate a CIPM key comparison with the other NMIs capable of measuring pipeline scale

natural gas flows. The result of this key comparison will establish the level of equivalence realized between the national flow standards for natural gas at pipeline conditions of other nations. Such equivalency is the basis for recognition and acceptance of calibration results among nations.

References:

1. ISO 9300:1990 (E), **"Measurement of Gas Flow by Means of Critical Flow Venturi Nozzles,"** ISO/TC 30, Measurement of Fluid Flow in Closed Conduits.
2. A. N. Johnson and T. Kegel, "**Uncertainty and Traceability for the CEESI Iowa Natural Gas Facility,"** NIST Journal of Research, 109, 345-369 (2004).
3. B. Mickan, et. al., **"Comparisons by PTB, NIST, AND LNE-LADG in air and Natural Gas with Critical Venturi Nozzles Agree within 0.05 %",** International Symposium of Fluid Flow Measurement (ISFFM) 2006 Conference.